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THE AEROMEDICAL FIELD LABORATORY:

MISSION, ORGANIZATION AND TRACK-TEST PROGRAMS

1958-1960

By David Bushnell

Historical Branch
Office of Information
Air Force Missile Development Center
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FOREWORD

These two chapters form a sequel, even though an incomplete one, to History of Research in Space Biology and Biodynamics at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1946-1958 (AFMDC Historical Office, December 1958). They cover the period roughly from mid-1958 to the latter part of 1960, but they do not cover the entire activity of the Aeromedical Field Laboratory at Holloman during the period in question. Chapter I--of which abridged versions have already appeared in the Holloman Monthly News Bulletin (of the Holloman Section, American Rocket Society) and in the ARDC Newsreview--principally discusses the changes that have occurred in the mission, organization, and personnel of the Holloman aerospace-medicine complex. Chapter II describes those test programs of the Aeromedical Field Laboratory that have made use of the 35,000-foot Holloman track.

Selection of bioscience track-test programs as the main aspect of the laboratory's activity to be covered in this short volume may seem at first glance to indicate a certain lack of proportion. During the years 1958-1960 such programs formed a relatively small part of the total track workload, and neither did they form the major part of the workload of the Aeromedical Field Laboratory. Nevertheless, they offer an extremely interesting example of the versatility of track testing in general and of the Holloman track in particular. Then, too, they conveniently touch upon all the major fields of endeavor in which the laboratory itself is now engaged: evaluation of personal equipment and satellite

systems for "biological adequacy;" physiological research on acceleration; selection, training, and conditioning of animal subjects for space-flight experiments. Furthermore, this topic provides an opportunity for giving some coverage both to the Holloman track, which is the most important single facility at the Air Force Missile Development Center, and to the Aeromedical Field Laboratory, whose work always possesses an unusually high intrinsic interest. From the standpoint of the harrassed Center Historian, who never seems to find time to record all the significant developments that come to his attention, this possibility of combined coverage is a very appreciable advantage.

Naturally, many individuals assisted in the preparation of this volume, whether by providing data or by some other contributions. To mention everyone would unduly prolong this Foreword, but special acknowledgment is due to Maj. Edward R. Regis, Lt. Albert Zaborowski, and Capt. Norman E. Stingely, all of the Aeromedical Field Laboratory, who not only answered miscellaneous questions but also reviewed different portions of the manuscript in rough draft for completeness and accuracy. To be sure, responsibility for the final version, as to both facts and interpretation, rests exclusively with the author.

David Bushnell
Center Historian
March 1961

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CHAPTER I

THE AEROMEDICAL FIELD LABORATORY

ORGANIZATION, PERSONNEL, AND THE BIOSATELLITE MISSION

By the middle of 1958 the Aeromedical Field Laboratory of the Air Force Missile Development Center, at Holloman Air Force Base, New Mexico, had won wide public and scientific attention with its research programs in biodynamics and space biology. Such achievements as the rocket-sled experiments of Col. (Dr.) John Paul Stapp, the series of animal and human balloon flights under the immediate direction of Lt. Col. (Dr.) David G. Simons, and the subgravity studies of Capt. (Dr.) Grover J. Schock and Dr. Harald J. von Beckh had established the Holloman laboratory as a small but essential contributor to the nation's progress in aerospace medicine. Since mid-1958, it has made fewer headlines, because the bulk of its work has been either less spectacular or else more sensitive from an information standpoint. But its total contribution certainly has not been less; indeed, the laboratory's workload, staff, and technical facilities have noticeably expanded during the last two years, and they are still expanding.

The Laboratory Mission

The most important underlying change that has taken place concerns the Aeromedical Field Laboratory's assigned mission. Under the direction of Colonel Stapp, who served

as Chief from April 1953 to April 1958, the laboratory performed both basic and applied research in biodynamics--relating principally to human and animal tolerance to short-duration g-forces--and essentially "pure" research on the biological effects of cosmic radiation and weightlessness. As of 1 July 1958, this mission was officially stated in the following terms:[1]

> Plans, coordinates, and accomplishes research in human factors of flight beyond the atmosphere and on the effect of mechanical forces encountered during flight on living tissues.

The mission had developed gradually and reflected both the particular research interests of Stapp and his co-workers and the presence of certain unique Holloman capabilities (e.g., for track testing and high-altitude balloon experiments). Nevertheless, in the post-Sputnik era, as the Air Force sought to accelerate the United States biosatellite program, the existing laboratory mission was thought to conflict with the most efficient mobilization of Air Force-wide resources in the field of aerospace medicine. Higher headquarters preferred to concentrate research efforts in this field at the Aero Medical Laboratory of Wright Air Development Center (now Aerospace Medical Division of Wright Air Development Division) and at the United States Air Force School of Aviation Medicine (now part of the Aerospace Medical Center, Brooks Air Force Base, Texas). This meant that the Aeromedical Field Laboratory at Holloman would emphasize test and operational-support functions on behalf of other military and civilian organizations; research _per se_ would be demoted to a secondary role.

The new mission took shape, by stages, in the summer of 1958. It still included some research among the objectives

of the Aeromedical Field Laboratory, but mainly in the areas of biodynamics for which the laboratory was uniquely equipped by virtue of test facilities located at Holloman, and to the extent that funds and manpower were available after meeting the requirements of still higher-priority functions. The latter included testing of personal equipment, capsule and escape systems, and the like for "biological adequacy;" and a broad range of operational support, including biological specimen support, for the nation's biosatellite program.[2] The laboratory acquired a considerably longer mission statement which did not once use the word "research"* and in general stressed technical services:[3]

> Develops improved techniques for human factors track testing procedures and instrumentation. Is responsible for determining human physiological tolerances to abrupt accelerations. Develops methods and procedures for testing biosatellite capsules and components. Maintains adequately conditioned series of biological specimens for all track, chamber, and biosatellite test operations. Provides pre- and post-test clinical evaluation of test specimens. Coordinates and directs the biosatellite test programs.

In due course, the over-all mission of the Air Force Missile Development Center was also revised by higher headquarters to include the statement:[4]

> Maintain an aeromedical field laboratory suitable for research and testing in biodynamics, bioastronautics and related fields, and conduct tests in these areas. Provide prelaunch assistance, recovery and post flight examination and

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* To be sure, the reference to "determining human physiological tolerances" could be taken in practice to mean research, while the test and vivarium functions cited in the mission statement would normally have research data as their end objective even if the ultimate research responsibility were vested in some other military or civilian agency.

> observation of all biological specimens to the Air Force Ballistic Missile Division. Provide vivarium support to the Air Force R & D Program.

The adoption of the new mission of the Aeromedical Field Laboratory put an end to two of its projects: Project 7851, Human Factors of Space Flight, and Project 7857, Research in Space Bio-Sciences. These projects, for which Dr. Simons had served as project officer, contained the laboratory's in-house and contractual work in cosmic radiation, subgravity, and cabin-environment research. Both were phased out by the end of 1958. Responsibility for much of the work in question was shifted to the School of Aviation Medicine and (to a lesser extent) the Aero Medical Laboratory at Wright Field.* For example, management of over $100,000 in university research contracts negotiated under Project 7851 was now transferred to the School of Aviation Medicine.[5]

A more complicated problem was posed by Project 7850, Biodynamics of Space Flight, which included essentially all those aspects of the previous laboratory mission that were to be retained either in the same or in somewhat altered form. Headquarters Air Research and Development Command proposed in July 1958 to abolish the project as such and redocument Holloman work in biodynamics as a subordinate task of Project 7222, Biophysics of Space Flight (now simply Biophysics of Flight), which was an activity of the Aero Medical Laboratory. As explained officially:[6]

> In order to redistribute the present workload of the Aeromedical Field Laboratory, AFMDC, so that

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* I.e., Wright-Patterson Air Force Base, Ohio, seat of the Wright Air Development Division and of its predecessor, the Wright Air Development Center, not to mention its predecessor's predecessors. In view of the instability of Air Force organizational designations, a shorthand term such as Wright Field is extremely convenient even if technically loose.

> its mission be made commensurate with available resources, it is necessary that Project 7850, Biodynamics of Human Factors in Aviation [sic] be terminated as a project.

Command headquarters felt that the expanded Project 7222 should "reflect the complete Air Force R & D program in the area of biophysics and biodynamics," using Holloman test facilities as needed but concentrating the direction of the program at Wright Field. This arrangement was opposed, however, by officials of Wright Air Development Center on the ground that management of a task at Holloman as part of a Wright Field project would become just too complicated.[7] The Aeromedical Field Laboratory opposed the suggestion too, naturally enough;[8] and it was finally abandoned.

Instead, Project 7850 was partly reoriented, in line with the new laboratory mission, and was also somewhat deemphasized, at least temporarily. But the over-all objective of the project was essentially unchanged:[9]

> ...to determine the limits of uninjured survival of the human body to brief applications of mechanical force. Accurate knowledge of the dynamic stress characteristics of the human body is a determining factor in criteria for design and specifications of aircraft and space vehicles where acceleration, pulsations, impacts and pressure differentials are imposed....

Except for the final elimination of Task 78507, Automotive Crash Forces--which was, however, a consequence of decisions made long before--the project's task structure also remained the same:

> Task 78503, Tolerance to Impact Forces, which sought both to "determine human tolerance to linear impact force with respect to rate of application, magnitude, and direction" and to evaluate particular escape systems and personal equipment for "biological adequacy;"

Task 78504, Tolerance to Total Pressure Change, which was still largely inactive, pending completion of specialized test equipment;

Task 78505, Tolerance to Ram Pressure and Thermal Effects, representing an extension of Colonel Stapp's windblast studies; and

Task 78506, Patterns of Deceleration in Space Flight, which was studying the use of water for attenuation of g-forces.

The redrawn project plan indicated that escape system testing and the testing of personal equipment for "biological adequacy" were new objectives for Task 78503; but they were not really new activities under the task program. They merely received special mention as a result of the project reorientation.* A statement that Project 7850 would support the National Aeronautics and Space Administration (NASA) was also new--because NASA itself was new. Another change was the deletion of "Space" from the project title, which now became simply Biodynamics of Flight. This reflected the fickleness of Air Force fashions with regard to the use of "Space" in project titles but had no far-reaching significance.

In 1959 another revision was made, in which Task 78503 became Human Tolerance to Escape Force Parameters. This occurred after Headquarters Air Research and Development Command halted the Aeromedical Field Laboratory's high-speed

* Although methods have varied in the past, current practice is to document all tests related to, say, a new seat or harness configuration for a particular aircraft under the respective weapon system or other program. Such tests would be cross-documented, however, under Project 7850. A comparable procedure is followed in the case of tests performed on behalf of different agencies but related to the other projects of the Aeromedical Field Laboratory.

track studies of ram pressure and thermal friction--in effect, windblast--and proposed instead a series of sled experiments to determine tolerance parameters for "encapsulated ejection systems." In line with this recommendation, the revised Task 78505 was to study "high amplitude, low frequency oscillations combined with longitudinal deceleration," with human and animal subjects. To avoid duplication, escape-system testing was now dropped from the list of objectives of Task 78503, although much of the work conducted by the latter task, particularly on the Daisy Decelerator, would continue to have a direct application to escape problems.[10]

Although Project 7850 did not, in the end, become a mere task of Project 7222, it has always required close coordination with related activities at Wright Field. Early in 1960, under the command reorganization instituted by Lt. Gen. Bernard A. Schriever after becoming Commander of the Air Research and Development Command, command management responsibility for Project 7850 was delegated to the Wright Air Development Division. Some months later, however, the project was brought directly under the cognizance of Brig. Gen. (Dr.) Don Flickinger, General Schriever's Assistant for Bioastronautics, and the role of Wright Air Development Division again became one of coordination rather than management.[11]

The changed laboratory mission also led to the establishment of two new projects, of which the first was Project 6892, bearing the awkward title Biomedical Test and Techniques for Advanced Vehicles. The original project plan, dated 19 December 1958, was approved by command headquarters on 4 February 1959. The stated objective was:[12]

> ...to insure the biological adequacy of all systems intended for space flight, including orbital flight, through development of required testing methods,

operational techniques, bioelectronic measuring techniques, and extraction of the maximum amount of post-mission information.

Specifically, the new project consisted of the following tasks:

Task 68920, Biological Specimen Support, relating to vivarium development and physiological baseline studies on different categories of test animals;

Task 68921, Altered Environments for Biological Specimens, which sought to "establish tolerance and performance data on biological specimens exposed to unusual environments" and to "provide subjects conditioned to specific physiological, handling, and restraint requirements;"

Task 68922, Post-Mission Analyses of Biological Specimens;

Task 68923, Operations Techniques; and

Task 68924, Space Vehicle Test, which sought to "test space vehicle system and subject compatibility to insure the physiology of the subjects are [sic] not exceeded."

Within a year the project had dropped Task 68923, which was combined with Task 68924, and added Task 68925, Biophysical Measurements [or Bio-Electronics], and Task 68926, Biological Dosimetry of Ionizing Space Radiations. This last task was not, strictly speaking, a revival of the basic cosmic-ray research previously performed under Project 7851. It had to do with the development of measurement systems, and it thus typified the over-all reorientation of the laboratory mission toward primary emphasis on biosatellite support rather than on research *per se*. However, the difficulty of making clear-cut distinctions between test-support and research functions is shown by the fact that one of the contractual studies

initiated under this task aims to determine (by means of laboratory experiments using various linear accelerators) the relative biological effectiveness (RBE) of energetic particulate radiations. Such a study really constitutes basic research in its own right, even though the immediate objective was simply to incorporate the resulting RBE values into a biologically-significant radiation monitoring system being developed for experiments in space.[13]

The laboratory's other new project is Project 6893, Animal Performance in Space Environments, whose original project plan was dated 23 December 1959. Its formal objective is to "develop equipment for measuring animal performance during space flight and to assess animal behavior as it is affected by unusual environments"--i.e., environments such as weightlessness, multi-g acceleration, and the temperature and humidity conditions to be encountered in space flight. Activities include training of animals, development of both data-collecting and test apparatus, and careful evaluation of the "effects of environmental insult upon animal performance." The project's two subdivisions are Task 68930, Animal Performance Equipment Development, and Task 68931, Animal Behavior Research in Space Environments. Command management responsibility for both Project 6893 and Project 6892 was transferred early in 1960 to the Air Force Ballistic Missile Division, which is the operational agency for Air Force biosatellite work; but it subsequently reverted to General Flickinger's office at Headquarters Air Research and Development Command, as also happened in the case of Project 7850.[14]

Project 6893 absorbed any performance-study aspects of Project 6892, whose project plan was revised accordingly. It also took the place of Task 71587, Animal Performance

Under Environmental Extremes, of Wright Air Development Division's Project 7184, Human Performance in High Altitude Flight.[15] Its establishment thus reflected the transfer of one portion of the Wright Field mission in life sciences to the Aeromedical Field Laboratory at Holloman; and this transfer reflected, among other things, the assignment to Holloman of a key role in the National Aeronautics and Space Administration's Project Mercury. NASA recognized that it needed the help of existing military organizations in carrying out the required preliminary program of animal experiments to "define and evaluate a range of physiological and psychological problems pertinent to manned space flight." Mr. Robert R. Gilruth, Director of Project Mercury, stated further (in a letter of 2 June 1959 to the Commander, Air Research and Development Command):[16]

> ...we feel that the Aeromedical Field Laboratory... is eminently qualified to provide the required overall management, and it is accordingly requested that they be authorized to assume this position and provide appropriate support in the Project Mercury animal program. It is further requested that such other Air Force organizations as may be determined by AMFL to be required for special services and equipment be authorized to participate in this program.

Headquarters Air Research and Development Command agreed to accept the NASA proposal, but General Flickinger, Assistant for Bioastronautics, pointed out certain difficulties in a letter of 19 June which he addressed to the Commander, Wright Air Development Center. He noted that the Aeromedical Field Laboratory was well equipped to manage the animal flight test program for Project Mercury in that it possessed "the only colony of large primates in the Department of Defense;" furthermore, it had a broad "background

of research experience" in acceleration studies and similar fields.* What it lacked was "a staff to condition and train large primates." General Flickinger added that the Aero Medical Laboratory of Wright Air Development Center held primary responsibility within the Command "for animal training and studying their behavior in unusual environments," but that it was not feasible either to move the Holloman primate colony to Wright Field or to establish a new colony there to meet the Command's "commitments to NASA."[17]

The solution outlined by General Flickinger, and duly adopted, was to transfer the necessary personnel, functions, technical equipment, and funds from the Wright Field laboratory to its Holloman counterpart. Wright Air Development Center agreed to expedite the move, which entailed the immediate reassignment of seven people to the Air Force Missile Development Center in the period July-September 1959. During subsequent months, the laboratory continued to build up its capability in the field of animal psychology--and not, of course, purely for Project Mercury support. These developments would enable it to support other programs as well, and they were a logical outgrowth of the revised laboratory mission; yet it was Air Force participation in Project Mercury that brought matters to a head.[18]

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* Neither Gilruth nor Flickinger specifically mentioned in their letters the support already given by the Aeromedical Field Laboratory to the Air Force's own Project Discoverer animal program (and in particular to the ill-fated Discoverer III experiment of 3 June 1959, which was the United States' first attempt to launch a biosatellite). But this was clearly a factor in the assignment to the Holloman laboratory of a role in Project Mercury.

Personnel, Organization, and Facilities

Changes in the mission of the Aeromedical Field Laboratory have roughly coincided with certain changes in key personnel and organization. John Paul Stapp left Holloman in April 1958 to become Chief of the Aero Medical Laboratory, Wright Air Development Center. Dr. Simons then headed the Aeromedical Field Laboratory on a provisional basis until the arrival in June 1958 of the next Chief, Lt. Col. (Dr.) Rufus R. Hessberg. A graduate of Yale University and Albany Medical College, Dr. Hessberg entered active duty with the Air Force in 1947; he served as flight surgeon and parasurgeon, making an important contribution to air rescue work both in the United States and in Europe. In the summer of 1955 he was transferred to Wright Air Development Center, where he served as Chief of the Aero Medical Laboratory's Escape Section and later headed that laboratory's entire Biophysics Branch. His Wright Field experience both in escape studies generally and in multi-g acceleration experiments using the human centrifuge ably fitted him for his next assignment, at Holloman.[19]

The Center-wide reorganization that went into effect on 1 September 1958, only a few weeks after Dr. Hessberg's arrival, naturally affected the Aeromedical Field Laboratory. Previously, it had formed part of the Center's Directorate of Research and Development and comprised three separate branches: the Space Biology Branch, headed by Dr. Simons; the Biodynamics Branch, headed by Capt. (Dr.) John D. Mosely, who came to Holloman in 1956 and collaborated with Colonel Stapp in all his later high-speed track experiments with animal subjects; and the Research and Development Services Branch, or Laboratory Services Branch as it was more frequently

called in practice, which was headed by Capt. (Dr.) James E. Cook and had immediate charge of the Holloman "zoo" of test animals.[20] After 1 September 1958, the Aeromedical Field Laboratory belonged to the new Directorate of Advanced Technology (the former directorate having been abolished) and had not three branches but four. One of these, the Veterinary Services Branch, was really the same as the former Research and Development [Laboratory] Services Branch and was still headed by Dr. Cook. An Administration Branch headed by Capt. Druey P. Parks and a Satellite Operations Branch under Dr. Mosely were innovations, although the first of these two represented a new organizational subdivision rather than a brand new function. The Satellite Operations Branch was created expressly for the new biosatellite-support workload, including Project 6892 (whose project officer is again Dr. Mosely).[21]

The Biodynamics Branch gave not only its chief but also, at the outset, all its other staff members to the Satellite Operations Branch. It continued to exist on paper, but with no formally assigned personnel. The situation reflected deemphasis on the research program of Project 7850, which had been the prime function of the Biodynamics Branch. But at least this branch fared better than the Space Biology Branch, which was abolished outright along with Projects 7851 and 7857. Dr. Simons remained to wind up such unfinished business as the Man High III balloon flight and to work on final project reports; but in January 1959 he was transferred to the School of Aviation Medicine. Most other branch personnel moved to Satellite Operations.[22]

As of 1 April 1959, the Satellite Operations Branch was renamed Bio-Astronautics Branch. This change met the objections of Dr. Mosely and others to the former title, which

had an awkward set of initials and also seemed "confining," implying that the branch would be concerned only with problems of orbital (as distinct from lunar and interplanetary) flight. During the third quarter of 1959, still another unit, the Comparative Psychology Branch, was added to accommodate the experimental psychologists recently transferred from Wright Field. One of them, Maj. (Dr.) Frederick M. Rohles, Jr., became head of the new unit (as well as project officer for Project 6893). And in the last quarter of the calendar year, the Biodynamics Branch was reactivated, with Lt. Col. (Dr.) Hamilton H. Blackshear as chief. Dr. Blackshear, who had a long record of service as an Air Force medical officer, was newly arrived at Holloman from a previous assignment in Buenos Aires, Argentina. The Biodynamics Branch still was not as fully manned as the Bio-Astronautics Branch, but it did take back Project 7850, which meanwhile had been carried on as a part-time activity of the other branch, and it resumed primary responsibility for operation of the Daisy Decelerator and related test facilities.[23]

By mid-1960 there had been just one further change in the roster of branch chiefs: the replacement of Capt. Parks by Capt. Nat G. Bullard as head of the Administration Branch. However, the Aeromedical Field Laboratory's roster of key personnel included at least two other officials: Maj. Edward R. Regis, who has served as Assistant [to the] Chief since September 1958, and Dr. Harald J. von Beckh as Technical Advisor. Dr. von Beckh--who reached Holloman in January 1958 by way of Austria, the German Luftwaffe medical corps, Argentina, and the Martin Company--was at first primarily a project scientist in subgravity studies. With the phasing out of the Holloman subgravity research program, which had formed part of Project 7851, he assumed

a broader range of scientific and technical responsibilities for the laboratory.[24]

During the two-year period ending 30 June 1960, total personnel strength of the Aeromedical Field Laboratory rose appreciably. It was 46--12 officers, 13 airmen, 21 civilians--as of 1 July 1958; had risen to 57--16 officers, 18 airmen, 23 civilians--just one year later; and stood at 78--21 officers, 36 airmen, 21 civilians--on 30 June 1960.[25] These figures did not, of course, include manpower assigned to such organizations as the Center's Track Test Division or Stratosphere Chamber Branch but still supporting biomedical test activities. Nor do they include the group of employees of Land-Air, Inc.--averaging sixteen in mid-1960--engaged in instrumentation and mechanical support of the Aeromedical Field Laboratory under a White Sands Missile Range contract.[26]

The steady expansion of both staff and workload brought with it a definite space problem. The original bioscience complex was a group of small buildings, located in the North Area of Holloman Air Force Base, of which not one was entirely suitable for laboratory use. Moreover, the complex as a whole had clearly been outgrown by the first half of 1958. The Space Biology Branch therefore spilled over into part of a missile assembly building (Building 1265) which was a two-mile drive away.[27] That one branch was abolished soon afterward, but the overflow continued until the burgeoning requirements of the Central Inertial Guidance Test Facility at Holloman forced the Aeromedical Field Laboratory at the end of 1959 to evacuate most of its foothold in Building 1265 and take refuge in the immediately adjacent Building 1264. The latter was another missile assembly (and administration) building, and it, too, was scheduled for ultimate assignment to the Guidance Test Facility; the Aeromedical Field

Laboratory was supposed to "borrow" it, on a temporary basis. Meanwhile, when the Comparative Psychology Branch was formed, it had found room in one part of the North Area fire station--which, quite apart from all questions of adequacy, naturally added to the dispersal of laboratory functions. And the completion in December 1959 of a new warehouse, alongside the original aeromedical complex, did little to alleviate the over-all problem. The seriousness of the situation was underscored by Colonel Hessberg in October 1959 when he observed that the overcrowding and other limitations of the existing buildings had caused the "death of some of the valuable inbred animals and injuries to handlers of the larger animals."[28]

The one obvious solution was to build a new laboratory structure specially designed for biomedical research. This would eliminate the time-consuming and otherwise inconvenient practice of human and animal commuting between different segments of the laboratory complex that were spaced as much as two miles apart; it would also provide the Aeromedical Field Laboratory with a facility expressly designed for its requirements. Indeed, the need for such a building was apparent even before the establishment of the present laboratory mission. The Center obtained approval from the Air Research and Development Command, in April 1957, to include a $785,000 aeromedical laboratory in its fiscal year 1959 military construction program--although the project still received lower Command priority than a new base theater (which has not yet been constructed either). In August or September 1957 the laboratory building was knocked out of the construction program somewhere at higher headquarters, but similar efforts have been made each year since then--with a uniform lack of concrete accomplishments.[29]

Late in 1959, as the problem became ever more acute,

the campaign for a new building was intensified. Dr. Knox T. Millsaps, Chief Scientist of the Air Force Missile Development Center, personally took a hand in the matter and promoted a whole new flurry of briefings and brochures.[30] Headquarters Air Research and Development Command was sympathetic. But Headquarters United States Air Force remained hard to convince, urging that an alternative solution be found by modifying and adding to existing facilities. As explained in a message that was relayed to Holloman in September 1960:[31]

> In view of the position the Congress has taken during the past two years as concerns facilities in support of the aerospace medicine research program, we could not hope to obtain approval for a million dollar facility at Holloman.

This reasoning reflected an obvious fear of Congressional criticism over what might seem to be duplication of Air Force bioscience facilities between the Wright Field complex, Holloman, and the School of Aviation Medicine.* Whether Congress would really have objected is debatable--but the fear was genuine. On the other hand, every alternative seemed to be either more costly than a new laboratory building or otherwise of doubtful practicability. A favorite suggestion at higher headquarters was to assign the Aeromedical Field Laboratory permanent use of Building 1264 and shift further expansion of the guidance complex to the West Area of Holloman

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* It is true that there was at one point an actual duplication in name between the new facility proposed for Holloman, which was to be called "Bioastronautical Laboratory," and a unit with exactly the same title at the School of Aviation Medicine. The Office of the Surgeon General, United States Air Force, suggested that this problem be solved by calling the Holloman facility "Science Laboratory Medical, Field;" but it is safe to assume that when and if it is built some less awkward designation will be found.

Air Force Base, where certain buildings were being vacated by missile contractor companies whose test activities at Holloman had drawn (or were drawing) to a close.[32] But this scheme would entail some very expensive modifications both to Building 1264 and to the West Area facilities, not to mention subjecting the Central Inertial Guidance Test Facility to a further split between its major components. Thus the Air Force Missile Development Center continued to hope for reconsideration of the laboratory construction requirement, even though the prospects did not seem very favorable.[33] Somehow, of course, the Aeromedical Field Laboratory would find a way to accomplish its mission; nevertheless, the facilities problem was threatening to become a definite inhibiting factor.

NOTES

1. Manpower and Organization Division, AFMDC, Organization and Functions, 1 July 1958, Chart 32.

2. AFMDC staff briefing by Lt. Col. (Dr.) Rufus R. Hessberg, Jr., Chief, Aeromedical Field Laboratory, 8 September 1958.

3. Manpower and Organization Division, Organization and Functions, revision as of 1 October 1958, Chart 39.

4. ARDC Regulation 23-12, 1 June 1959.

5. AFMDC staff briefing by Lt. Col. Hessberg, 8 September 1958; Aeromedical Field Laboratory, "Historical Data," September-December 1958.

6. Ltr., Col. John R. V. Dickson, Asst. Dep. Cmdr./R & D, Hq. ARDC, to Cmdr., WADC, subj.: "Documentation of Bio-dynamics Effort of AMFL, AFMDC," 18 July 1958.

7. 1st ind., Stanley M. Birnbaum, Requirements Branch, DCS/O, WADC, 25 August 1958, to ltr. cited in preceding note.

8. Cf. Lt. Col. Hessberg, memo, subj.: "Telephone Call from AML, Wright Air Development Center...on 25 July 1958."

9. R & D Project Card (DD Form 613), Project 7850, 31 December 1958. Cf. Historical Branch, AFMDC, History of Research in Space Biology and Biodynamics at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1946-1958 (hereafter cited as Research in Space Biology and Biodynamics), pp. 65, 92-93.

10. Critique of 80-4 Documentation (ARDC Hq. Form 0157), Project 7850, by Col. Jack Bollerud, Dir./ Life Sciences, ARDC, 30 April 1959; comment no. 2, Maj. Herbert W. Simmons, Acting Chief, Programs Division, DCS/O, AFMDC, to Mr. Ellis M. Bilbo, Plans and Programs

Office, Dir./Advanced Technology, AFMDC, subj.: "Management Reports--Projects 6892 and 7850," 19 May 1959; R & D Project Card, Project 7850, 31 August 1959.

11. Interview, Capt. Eli L. Beeding, Project Officer, Project 7850, by Dr. David Bushnell, AFMDC Historian, 25 October 1960.

12. R & D Project Card, Project 6892, 19 December 1958.

13. Management Report (ARDC Form 111), Project 6892, 10 November 1959; R & D Project Card, Project 6892, 11 December 1959; Aeromedical Field Laboratory, "Historical Data," April-June 1959; memo Lt. Col. Hessberg to Mr. Bilbo, subj.: "FY 60 ARDC Annual Effectiveness Report," 24 June 1960.

14. R & D Project Card, Project 6893, 23 December 1959; TWX, Hq. AFBMD to Hq. AFMDC, subj.: [Project 6892], 22 January 1960; TWX, Cmdr., AFBMD to Lt. Col. Hessberg, subj.: [Project 6893], 30 March 1960.

15. R & D Project Card, Project 6892, 11 December 1959; R & D Project Card, Project 6893, 23 December 1959.

16. Ltr., Mr. Robert R. Gilruth, NASA, to Cmdr., ARDC, subj.: [Project Mercury Animal Program], 2 June 1959.

17. Ltr., Brig. Gen. Don Flickinger, Asst. for Bioastronautics, Hq. ARDC, to Cmdr., WADC, subj.: "Transfer of Responsibility," 19 June 1959.

18. _Ibid._; 1st ind. to Flickinger ltr., by William R. Grohs, Hq. WADC, 9 July 1959; Aeromedical Field Laboratory, "Historical Data," July-September 1959; AFMDC staff briefing, by Lt. Col. Hessberg, 4 August 1959.

19. _Holloman Rocketeer_, 18 July 1958; WADC Biographical Data, Rufus R. Hessberg, form consulted in files of WADC Information Office.

20. _Research in Space Biology and Biodynamics_, pp. 52, 95-97.

21. Manpower and Organization Division, _Organization and Functions_, revision as of 1 October 1958, Chart 39;

Aeromedical Field Laboratory, "Historical Data," September-December 1958. The original project officer for Project 6892 was Dr. Hessberg himself, but this role was assumed by Dr. Mosely soon after the project received formal command approval ("Historical Data," April-June 1959).

22. *Research in Space Biology and Biodynamics*, p. 65; interview, Capt. John D. Mosely, Chief, Satellite Operations Branch, by Dr. Bushnell, 10 October 1958; interview, Lt. Col. David G. Simons, by Dr. Bushnell, 13 January 1959.

23. Manpower and Organization Division, *Organization and Functions*, revisions as of 1 April 1959 and 1 October 1959, Chart 39; interview, Capt. Mosely by Dr. Bushnell, 10 October 1958; Aeromedical Field Laboratory, "Historical Data," July-September 1959 and October-December 1959; Biographical Data (AF Form 175), Hamilton H. Blackshear, 15 October 1959. Blackshear did not, however, become project officer for Project 7850. This role had been filled by Dr. Mosely, back in 1958, and subsequently by Capt. (Dr.) Grover J. D. Schock. When Schock left Holloman in the latter part of 1959, Capt. Eli L. Beeding was named project officer in his place. (*See* successive revisions of R & D Project Card, Project 7850.)

24. Aeromedical Field Laboratory, "Historical Data," September-December 1958 to present; various interviews, Dr. Harald J. von Beckh by Dr. Bushnell.

25. Aeromedical Field Laboratory, "Historical Data," July-August 1958, July-September 1959, and April-June 1960.

26. Department of the Air Force--Construction Project Justification Data (AF Form 161), "Science Laboratory, Medical, Field," 5 August 1960.

27. *Research in Space Biology and Biodynamics*, p. 96.

28. Aeromedical Field Laboratory, "Historical Data," October-December 1959; Lt. Col. Hessberg, "Air Force Missile Development Center...Medical Science Laboratory FY 61 MCP Category Code-310-291" (briefing presented to Hq. ARDC), 23 October 1959; data card on Building 1205, in Real Estate Section, Installations Division, AFMDC.

29. Interview, Mr. Fred W. Grefe, Acting DCS/Installations, AFMDC, by Dr. Bushnell, 13 October 1960.

30. See, e.g., A Place for Space? A Special Presentation of the Requirement for Construction of a Bioastronautical Laboratory at the Air Force Missile Development Center. This item was commissioned by Dr. Millsaps and actually put together by Dr. James S. Hanrahan, Center Historian, in December 1959.

31. Ltr., Col. Robert E. Smotherman, Director of Facilities, DCS/Materiel, Hq. ARDC, to Hq. AFMDC, subj.: "Laboratory Biomedical," 9 September 1960.

32. Ibid.; A Place For Space?, pp. 42-45. On the conflict in designations, see TWX, Hq. ARDC to Plans and Programs Division, DCS/Installations, AFMDC, subj.: [Title of Proposed Bioscience Facility], 8 August 1960.

33. 1st ind. to Smotherman ltr., signed by Col. Ralph S. Garman, Dep./Cmdr., AFMDC, 30 September 1960; interview, Mr. Grefe by Dr. Bushnell, 6 December 1960.

CHAPTER II

BIOSCIENCE TRACK-TEST PROGRAMS: 1958-1960

To a great extent the Holloman track is still primarily associated in the public mind with human deceleration and windblast experiments. This widespread though misleading impression is an incidental result of the most famous test-track experiment of all time, the Holloman sled ride of Colonel John Paul Stapp on 10 December 1954. It is true that on the original 3550-foot Holloman track more runs were made for biomedical research than for any other single purpose. But that research lost its preeminent role on the interim 5000-foot facility that was in operation from May 1956 to August 1957; and it ranks well below guidance-system testing among the activities using the present 35,000-foot Holloman track. On the other hand, the traditional association between the Holloman track and biomedical testing was fittingly symbolized by the selection of an animal acceleration/deceleration experiment for what was billed as the first run to cover the entire length of track, at the formal dedication of the 35,000-foot facility in February 1959. Moreover, while biomedical runs on the new track have been relatively few, they include not only windblast experiments that were a continuation of tests performed on the 3550-foot track but also certain new series of tests of unusual interest because of their relation to problems of space flight.

Completion of the Windblast Test Program

The first biomedical experiment on the new track took

place on 6 August 1958, in connection with the program of research on windblast which was conducted by the Aeromedical Field Laboratory of the Air Force Missile Development Center. This program formed Task 78505, Tolerance to Ram Pressure and Thermal Effects (until March 1958 simply Tolerance to Abrupt Windblast), of the laboratory's Project 7850, Biodynamics of [Space] Flight. It had begun in 1954 as part of Colonel Stapp's study of combined windblast and deceleration such as a flier experiences in high-speed escape from aircraft. In due course, high-g deceleration and supersonic windblast became the subject of separate test programs, with a lighter and faster sled, Sonic Wind Number Two (AFMDC 5503), designed and built for the specialized windblast tests. These remained oriented toward the aircraft escape problem, even after the deceleration experiments had developed into a program of more basic research on tolerance to g-forces.[1]

The last previous windblast experiment on the Holloman track had been conducted on 2 March 1956. This was just before the first track extension (to slightly over 5000 feet); and the next four experiments in the Aeromedical Field Laboratory's windblast series took place not at Holloman but on the Supersonic Naval Ordnance Research Track (SNORT) at China Lake, Calif. The naval test track was used because its 21,500-foot length permitted the attainment of substantially higher sled velocities than either the original 3550-foot Holloman track or the extended 5000-foot facility could offer. Velocity was, of course, the key ingredient for windblast experimentation--and the research program could not simply wait until Holloman's present 35,000-foot test track became available.

The first SNORT test was a checkout run of February 1957; but the other three were full-scale experiments with

anesthetized chimpanzee subjects at speeds in the neighborhood of mach 1.7. In each case the subject wore special protective clothing (including helmet) developed by the Aeromedical Field Laboratory with assistance from Protection, Inc., of Los Angeles (a division of the Mine Safety Appliances Co.). In each case the subject was lost, as the result of failure occurring somewhere in the combination of suit, helmet, and restraint harness, but each failure suggested improvements to be incorporated before the next test. All body areas that became exposed during the tests[2]

> ...received second or third degree burns....The lesion is characterized as a burn with no evidence of carbonization, and is considered as a new pathological entity.

On the other hand, the protective covering used was able to prevent such burns wherever it remained in place.

The last China Lake test, on 12 March 1958, was to have been followed by two more at the same location. However, the Navy professed inability to conduct these runs unless it received certain additional funds for which the Air Force had made no provision. The Air Force thus felt compelled to cancel the windblast test series at SNORT, and the remaining tests were simply transferred to the Holloman track, which was now in the final stages of its expansion to 35,000 feet. The move entailed some interruption but no really serious delays, and it meant considerable savings for the Air Force.[3]

Before the 6 August experiment at Holloman, the windblast sled Sonic Wind Number Two had to be retrieved from China Lake and readjusted to fit the wider gauge of the Holloman track. The Northrop Corporation, which had built the sled originally, performed necessary modifications and

also was commissioned to provide certain support services for the coming track experiments. In addition, Protection, Inc., delivered improved versions of the suit and helmet last used at China Lake. The suit's outer material was white dacron sailcloth, while the inner garment consisted of layers of wool, heat-resistant aluminized dacron, and cotton. The helmet was made of fiberglas and completely covered the head and face except for two half-inch portholes at eye level.

The protective suit had been built to the measurements of a particular chimpanzee from the Aeromedical Field Laboratory primate colony; and unfortunately the chosen subject died just before the originally scheduled firing time on the morning of 5 August 1958. Apparently this result was due to the long anesthesia combined with overheating in the special suit during prerun preparations; later autopsy revealed an abscessed wisdom tooth as a further complication. The next step was to reschedule the experiment and call in a back-up chimpanzee subject, and the suit did not fit quite so well. Indeed it was necessary to remove some layers of material from the right arm, which naturally reduced the degree of protection offered.[4]

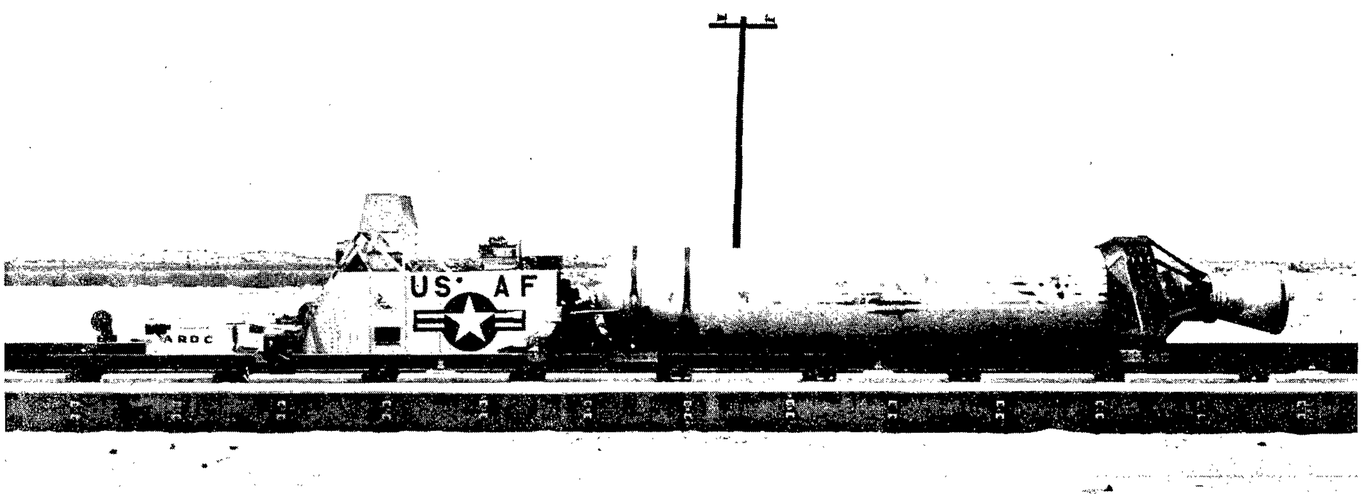
The run was programmed to reach approximately the same speed as the last three SNORT runs, with moderate acceleration/deceleration levels so that g-forces experienced would not overshadow the supersonic wind pressure. Propulsion was supplied by a Megaboom solid-propellant rocket motor, approximately 22 feet long and capable of delivering 100,000 pounds of thrust during its ten-second firing period.[5] Instrumentation included the track's new light-beam-interrupter velocity measuring system, cameras, telemetry, sled-borne recording equipment, and an assortment of thermometers and

other gauges. The sled was finally fired on 6 August 1958--from the far north end of the Holloman track. It traveled 20,014.3 feet, and reached a maximum velocity of about 1740 feet per second.[6]

The subject survived the run without difficulty.* Its right arm was burned somewhat, where part of the protective garment had been cut away, but the rest of the suit and the helmet gave full protection against the supersonic windblast. Temperature exceeded 100 degrees centigrade as measured on the bow of the sled and rose as high as 93 degrees centigrade on the subject's chest outside the suit; but the maximum that was measured inside the suit was only 48. The restraint system also held up, so that there was no injury from flailing. The experiment was therefore considered a complete success. From the scientific standpoint, moreover, the trouble in fitting suit to subject was really an advantage, because the subject's right arm provided a useful control experiment.[7]

Having established that a living subject could be successfully protected against windblast in the vicinity of mach 1.6, the Aeromedical Field Laboratory was ready to consider the definitive experiment--with a human being. First, however, it was necessary to make a new suit and helmet, similar to the ones used in August but built to human measurements; and this equipment was then tested on a carefully instrumented 165-pound anthropomorphic dummy in a track run held 29 October 1958. The general pattern of the test was the same as before, although top speed was slightly less (around 1600 feet per second). Once again the protective equipment proved highly successful.[8] Since

* The chimpanzee died considerably later, from an ailment unrelated to track testing.



SONIC WIND NUMBER TWO/MEGABOOM AFTER 6 AUGUST 1958 WINDBLAST EXPERIMENT

PREPARING ANTHROPOMORPHIC DUMMY FOR 29 OCTOBER 1958 EXPERIMENT

dummies are less controversial than animal test subjects, this run was also quite widely publicized. The dummy was described in at least one journal as wearing a "space suit,"[9] which was not literally correct but did suggest the highly futuristic appearance of the suit/helmet combination. Of course the choice and arrangement of materials could very well prove instructive for space-suit design, even though escape from aircraft was intended as the immediate research application.

The dummy (and protective equipment) used on 29 October had been modeled after one human in particular: Capt. (Dr. and later Maj.) John D. Mosely, who had collaborated with Colonel Stapp in his later high-g experiments with animal subjects on the Holloman track and was also task officer for the China Lake windblast tests. In effect, Mosely was the intended subject for a human windblast experiment at almost twice the speed attained by Colonel Stapp on his last and most famous Holloman sled ride of December 1954. But this experiment never did take place. At higher headquarters it was felt that much valuable information had been obtained already on windblast protection, and that the need for a human experiment at supersonic speed was not sufficiently pressing to justify the risk involved. Dr. Mosely's ride was therefore vetoed by the Air Research and Development Command early in 1959; and the practical effect of this decision was to terminate the Holloman windblast test program, at least for an indefinite period.[10]

Command headquarters now suggested that the effort of Task 78505 "should be reoriented to the use of [escape] capsules." Although Colonel Stapp (who headed the Holloman laboratory until April 1958) had been a confirmed

skeptic on the subject of closed or "encapsulated" escape systems, Air Force thinking on the escape problem assumed that high-performance aircraft would be equipped with them sooner or later. So would any true space vehicle that made provision for abandoning the craft during exit or re-entry. A closed system would of course do away entirely with any direct exposure of the flier to windblast; but it would still leave him exposed to other potentially damaging forces such as those developed from abrupt air-drag deceleration. Accordingly, the Aeromedical Field Laboratory redocumented Task 78505 of Project 7850 as Human Tolerance to Escape Force Parameters. The revised task was to study "high amplitude, low frequency oscillations combined with longitudinal deceleration," under different combinations of position, restraint, and force/time. The test program was to include track experiments with human and animal subjects; and in mid-1959 a contract was awarded to the Northrop Corporation for a design study of a "Subject Carrying Oscillator," which could be mounted on a multiple-purpose rocket sled. However, on completion of this contract it was decided that the equipment, as it had been envisioned, was not entirely practical,and the track-test phase of the revised task program therefore still remains in the planning stage.[11]

Sled-Vibration and G-Protection

One of the two sled runs conducted at the official dedication of the 35,000-foot Holloman track, on 25 February 1959, was in part related to the windblast test program. At that time, the plan to conduct a human windblast test

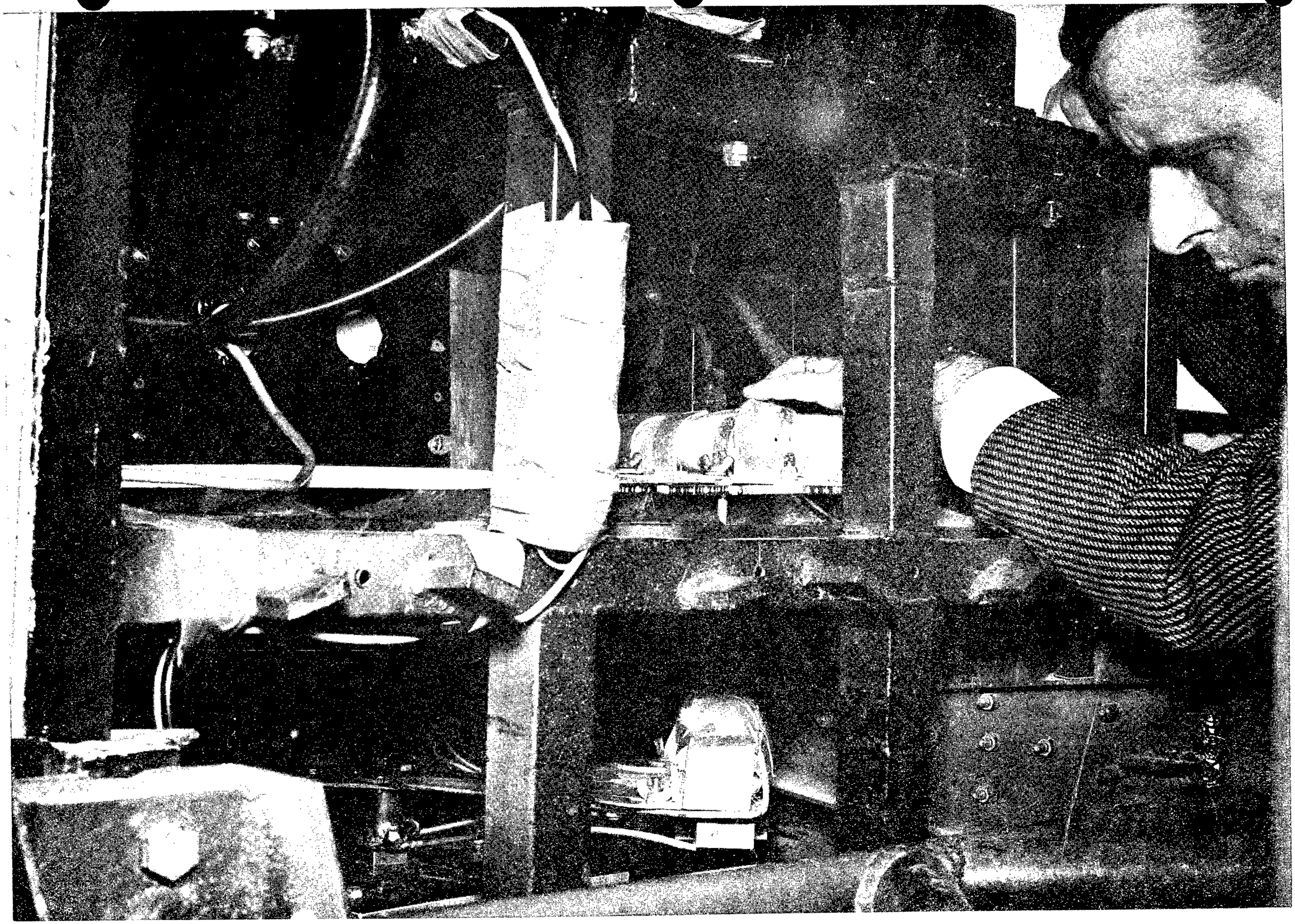
had not yet been cancelled, and it seemed desirable to run the sled Sonic Wind Number Two without either a living or a dummy subject but instrumented at several points to obtain some additional data on vibration characteristics of the sled itself.[12] Such data would be helpful for planning and evaluation purposes, in connection with windblast studies or any other research program for which the sled might be used. And the experiment was quite appropriate for inclusion in the dedication ceremonies, since the sled was a high-performance vehicle which had already played an important part in the history of Holloman track testing.

Some days before it took place, the planned vibration/dedication experiment acquired still another objective. In effect, the Aeromedical Field Laboratory chose this opportunity to make a further test of an anti-g device proposed by one of its civilian staff members, Dr. Harald J. von Beckh. The device was an "anti-g platform," designed to turn freely and to position its occupant automatically at all times so as to receive g-forces in the more tolerable transverse direction rather than parallel to the long axis of the body. Dr. von Beckh had originally proposed that such a system be adopted in manned capsules for escape from high-performance aircraft, but it would be equally applicable for use in space vehicles. After coming to Holloman in January 1958, he devised a simple swinging platform capable of testing the basic principle of his suggestion with small animal subjects, and this platform had already been "free-loaded" on various runs on the Daisy Decelerator. It was now to have its first trial on the Holloman long track. Two rats were picked as subjects, one to ride the "anti-g platform," the other to go along as a control. Indeed the control rat not only was denied the benefit of an "anti-g

platform" but was to ride the sled lengthwise, i.e. in a less tolerable orientation.[13]

When 25 February arrived, one part of the dedication festivities was a short address by Lt. Col. (Dr.) Rufus R. Hessberg, Chief of the Aeromedical Field Laboratory, on the use of the high-speed track for biomedical research. This was one of various talks presented before a distinguished audience that gathered from far and wide to witness the day's events and included a half dozen general officers as well as two members of the United States Congress. And at 1155 hours Maj. Gen. Leighton I. Davis, Deputy Commander for Research, Air Research and Development Command (and former Commander of the Air Force Missile Development Center) pressed a button to start the run by Sonic Wind Number Two. This was supposed to be the first run to cover the entire length of track, although lesser portions of the new facility had been in service since August 1957.[14] In practice, the sled was fired from the north end of the track and came to a stop at the 5885-foot mark--i.e., almost 6000 feet from the south end, and less than 30,000 feet from the firing point. Propelled once again by a Megaboom rocket motor, the sled attained maximum velocity of 1599 feet per second, and both the acceleration and the water-brake deceleration were about ten g. Among the lesser incidents of the run, the sled lost one of two antennas--and it hit a bird.[15]

The run also achieved its original objective in that it provided some more vibration data on Sonic Wind Number Two. But this data was never reduced, since shortly afterward the windblast test program was halted. For that matter, neither has the vibration data been reduced that was obtained on the two windblast runs of 6 August



DR. HARALD von BECKH IN FINAL PRERUN INSPECTION BEFORE RAT EXPERIMENT OF 26 FEBRUARY 1959.
SLED IS SONIC WIND NUMBER TWO; BOTTOM RAT IS MOUNTED ON SWINGING ANTI-g PLATFORM.

and 29 October 1958.[16]

The vibration measurements, in any case, were overshadowed by Dr. von Beckh's rat experiment. Certainly no other single aspect of the track dedication attracted so much journalistic attention: even The New York Times put its story of the ceremonies under the caption, "Two Rats Survive Rocket Sled Test."[17] In general, press accounts of the rat experiment were rather garbled, and they were somewhat misleading when they emphasized that the platform-mounted rat was in good shape after the run whereas the control rat was suffering "internal disturbances."[18] The platform functioned properly, but neither rat was in serious difficulty, and it is at least conceivable that the control rat was in better shape than its companion. Nor was there really any reason to expect that a ten-g force would have a harmful effect on rodents, whose overall g-tolerance is considerably higher than that of human beings. Rats had been exposed to much higher force levels in similar experiments using the Daisy Decelerator. Indeed it is quite possible that the acceleration/deceleration experienced on the 25 February run had less physiological significance than the noise generated by the huge Megaboom rocket motor and the vacuum that was created between the rocket and the open back end of the sled (where the two rats were located).[19]

Discoverer Track Tests (Snowball)

The 25 February run described above actually came after the first two of a group of six track tests held in support of the United States Air Force Project Discoverer. This

project, which in August 1960 achieved the world's first successful recovery of a capsule from orbit, is an outgrowth of Air-Force-sponsored studies going back to 1946 on the feasibility of reconnaissance satellites. In late 1958 Discoverer was separated from the main reconnaissance-satellite effort, becoming a more general program for development and testing of systems and techniques for satellites and other space vehicles. The agency immediately in charge was the Air Force Ballistic Missile Division, but Discoverer was definitely not "operationally oriented;" it was concerned basically with advancing the state of the art.[20]

Among the various aims of Project Discoverer was to develop an Air Force biosatellite capability. In this respect the Aeromedical Field Laboratory at Holloman had a key supporting role to play, because in the summer of 1958 the Air Research and Development Command had redefined the mission of the Holloman laboratory, placing emphasis on direct support of biosatellite efforts. In particular, the Aeromedical Field Laboratory received an assignment to test satellite systems and subsystems for "biological adequacy" and to provide biological specimen support as needed for both pre-launch testing and actual flight experiments.[21]

A life-support system intended for Discoverer satellite experiments was accordingly tested at Holloman starting in January 1959, using the stratosphere chamber and Daisy Decelerator as well as the high-speed track.[22] Over-all responsibility for the test program was entrusted to the Aeromedical Field Laboratory, which handled it as an activity of Project 6892, Biomedical Test and Techniques for Advanced Vehicles. In the high-speed track phase of

the Discoverer program, moreover, requirements were such as to tax the ingenuity of both laboratory personnel and Holloman track engineers. It was necessary to simulate, in compressed form, the complete acceleration/deceleration profile of a satellite vehicle. This was something that a track could do better than any other test device, but the difficulties were still impressive. Specifically, the test program called for:[23]

a. First-stage motor ignition.
b. Thrust and acceleration build-up during first-stage burning.
c. First-stage motor burnout with resultant loss of acceleration.
d. Second-stage motor ignition.
e. Second-stage thrust and acceleration build-up.
f. Second-stage burnout.
g. Coast phase simulating vehicle without thrust.
h. Deceleration simulating satellite re-entry.

Each of the two thrust stages was supposed to build up smoothly to a peak of around ten g, thus simulating the magnitude though not the duration of the expected satellite acceleration. Subsequent deceleration was to reach roughly the same level.[24]

The sled chosen for this test series was the general-purpose, solid-propellant Coleman sled (AFMDC 5801), which had not been used since a booster explosion of August 1958 and had recently undergone rather extensive repair and modification.[25] The main propulsion for each stage was a cluster of Viper II-C rockets (8200 pounds thrust each); but smaller and faster-burning Loki rockets (3350 pounds thrust each) were added, to fire <u>forward</u> (i.e., as retrorockets) and smoothe the Viper thrust curve. Equally unusual was the use of water braking not merely for the final deceleration phase but also during the propulsion phase in order to use up excess thrust, which would otherwise have reached about 30 g.

Water braking was in fact required during most of the run, except for the coast phase, with intricately-varying water-dam heights.

After careful planning and preparation, a checkout run was made on 6 January 1959. The desired run profile was obtained up through the first-stage acceleration, but not for the remainder of the test. Not only was Viper II performance less than expected, but water-brake parameters had been estimated incorrectly. In addition, the use of water braking over the greater part of the run created a heavy spray that interfered with data gathering by ribbon-frame cameras and probably also accounted for the lack of usable data from the track velocity measuring system. On the other hand, good telemetry and sled-borne recorder data were obtained. Maximum velocity (as indicated by break-wires and Berkeley counters) was a mere 275 feet per second--considerably less than programmed, although velocity *per se* was not a major consideration.[26]

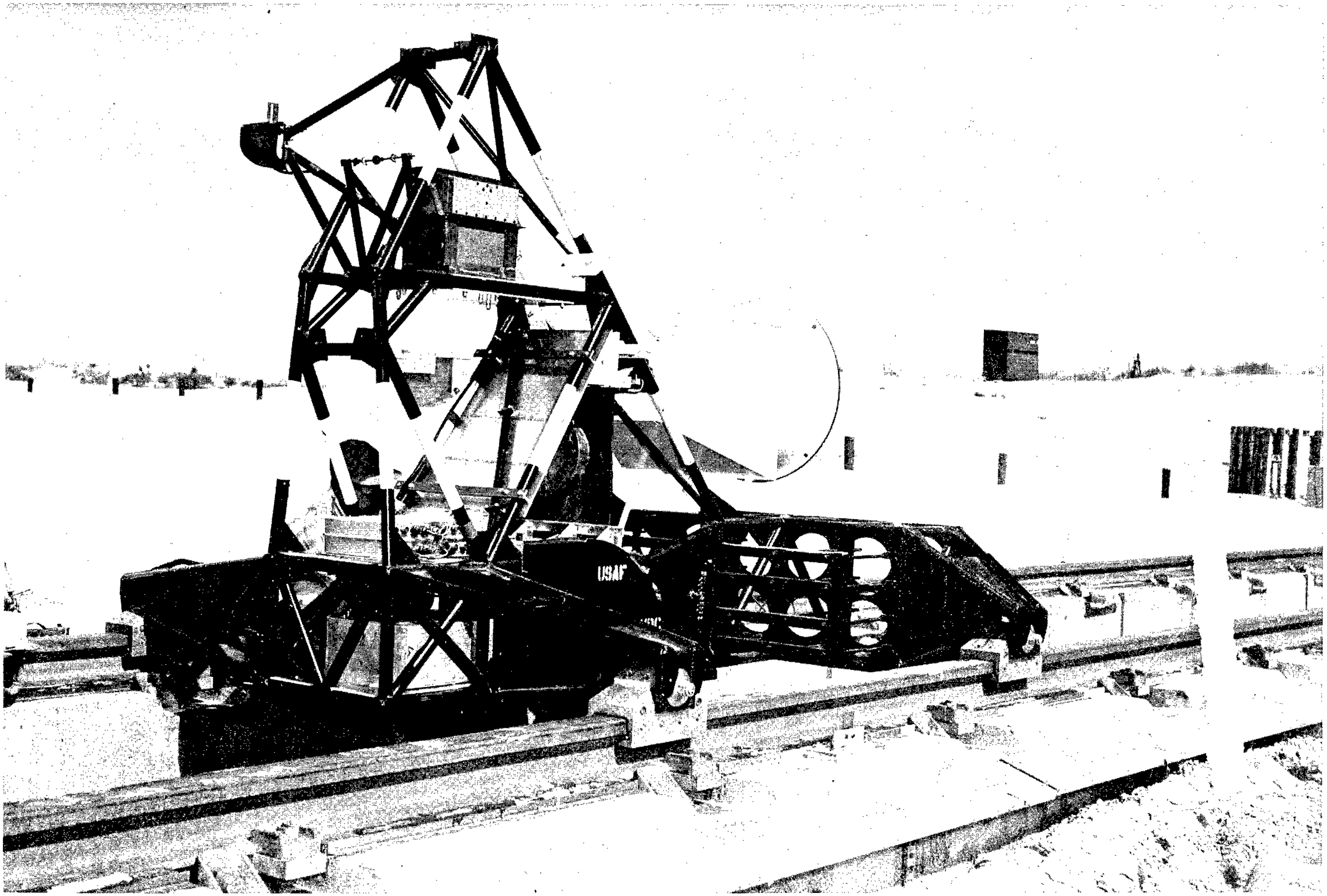
The next run took place on 13 January, after appropriate modifications were made to the water-dam settings, and carried a biological payload. Four mice from the Aeromedical Field Laboratory vivarium were placed inside the Discoverer life-support system--whose white, spherical appearance gave the code name Snowball to this test program--and were mounted on the Coleman sled. The desired first-stage profile was attained again, and the second stage was "fairly closely simulated." The final or deceleration phase of the run failed to achieve the desired magnitude of g, because the sled had failed to attain programmed velocity; but the peak velocity of 368 feet per second was at least higher than in the previous experiment. To be sure, the increase in speed meant more water spray during

the run and even less satisfactory data collection. Nevertheless, while recognizing that there was room for improvement, the Aeromedical Field Laboratory professed to be satisfied with the run. The mice, on their part, showed no sign of any adverse effects.[27]

In May of the same year another group of runs (Snowball II) was conducted for Project Discoverer. Although the test objectives were comparable, certain changes had been made in the life-support system, and a new variety of subject was used on the final, live run. A different sled was used too: the Lockheed sled (AFMDC 5703), which had been designed originally for sled tests of an experimental ejection seat.* Among other things, it was lighter than the Coleman sled and thus cheaper to operate. Another change was to simulate the spiked ten-g satellite acceleration pattern by means of water-brake deceleration, at the end of the run. The satellite re-entry pattern was not expressly studied in this second series--indeed the Lockheed sled was not well suited for simulating both launch and re-entry in a single run--but it was still reproduced, very roughly, by the rocket-sled acceleration.[28]

The first Snowball II checkout run was held 15 May 1959. For propulsion it used three Sparrow (1.8 KS 7800) rockets in a single stage, and it reached a top speed of 580 feet per second. Sled acceleration was ten g, deceleration came to slightly over four g. The run thus failed to meet profile requirements, apparently because the final sled weight

* This sled was actually built by the Northrop Corporation. The name Lockheed reflects the fact that it was built for tests of an ejection seat which was under development by the Lockheed Aircraft Corporation. These tests took place in the spring of 1957, and the sled had not been used since.



LOCKHEED SLED, SHOWING SPECIAL MOUNT FOR DISCOVERER LIFE-SUPPORT CAPSULE (*Snowball II*).

was heavier than expected and because of incorrect water-brake calculations. The next attempt, on 25 May, made use of four Sparrows instead of three; but two of them failed to fire, because the booster crew had failed to remove a shorting screw in the igniter circuit. Top speed was 361 feet per second, and again the profile was not achieved.[29]

On 26 May, on the third attempt, everything went more or less as scheduled. All four rockets fired, speed was 717 feet per second. There was some slight structural damage to the Snowball II package mount, but the run gave "a very acceptable profile." Thus on 29 May the live run took place, with a small monkey (supplied in this case by the Ballistic Missile Division) as subject. As an additional payload, the sled carried a life-support capsule developed by the United States Air Force School of Aviation Medicine. It was a system intended for use in animal rocket experiments and was quite similar to the Discoverer capsule except for being cylindrical rather than spherical in shape. The School of Aviation Medicine had also hoped to test its capsule with an animal subject, but the latter could not reach Holloman in time; however, the unoccupied capsule could and did undergo a structural test. The run profile was again successful, with 732 feet per second maximum speed followed by two deceleration spikes on the order of ten g. Both life-support systems stood up well under the test, and so did the monkey.[30]

These tests on the Holloman high-speed track were of course just one aspect of Air Force preparations for Discoverer biosatellite activity. But it is still worth noting at this point that when Project Discoverer launched the first United States satellite with a living payload, on 3 June 1959, the passengers were four mice chosen from a select group of

mouse subjects at the Aeromedical Field Laboratory.[31] They were all black rather than white mice, since plans called for measuring the amount of hair-graying caused by space radiation, on bringing the mice back down from orbit for scientific study.

The mouse-carrying satellite was only the third Discoverer to be launched, and in practice no Discoverer capsule was successfully recovered until "lucky thirteen" on 10 August 1960. Nevertheless, it was felt that some chance existed for a successful recovery on Discoverer III--at least enough of a chance for the effort to be worth making. The recovery attempt on Discoverer II (launched 13 April 1959), whose instrument capsule ejected prematurely near Norway, was believed to have failed because of a human error in signaling, and this seemed easy to correct.[32] Accordingly, Holloman mice and technicians were deployed to Vandenberg Air Force Base, Calif., for the launch attempt, and two officers of the Aeromedical Field Laboratory--Capt. James E. Cook and Capt. Druey P. Parks--even traveled to Hawaii to be on hand for mid-Pacific recovery operations.[33]

The launch was first scheduled for the middle of May 1959. After several postponements, Discoverer III blasted off on 3 June--and was never seen again.[34] Although the launching had seemed outwardly successful, the satellite failed to achieve orbit "because of less than nominal second stage performance and incorrect Pt. Mugu radar data indicating firing time."[35] On the other hand, telemetered data was received on the four mice during rocket acceleration and a short period of coasting. The data indicated, as far as it went, that the mice had not suffered any ill effects from multi-g acceleration, weightlessness, or other "normal" conditions of space flight. Presumably they were cremated

as the satellite plunged back prematurely into the atmosphere, and this of course came under the heading of accidental death.[36]

Fluid-Capsule Experiments

One of the most interesting and unusual test programs to be conducted on the Holloman track is a series of experiments dealing with the use of water for attenuation of g-forces. These experiments are an activity of Project 7850's Task 78506, Patterns of Deceleration in Space Flight, and Lt. Albert V. Zaborowski, of the Aeromedical Field Laboratory's Biodynamics Branch, has been task officer since the program was initiated in the first half of 1958. In some respects this experimentation parallels the widely publicized work that has been accomplished on underwater acceleration by the Aerospace Medical Division at Wright Field and by the Navy's Aviation Medical Acceleration Laboratory at Johnsville, Pa. However, scientists at those research centers have been principally concerned with the effects of medium- or long-duration g-forces, as tested on the centrifuge. Holloman test facilities, by contrast, are ideally suited for studying the same protective technique under conditions of abrupt acceleration/deceleration, and the Aeromedical Field Laboratory has naturally moved to take advantage of this fact.[37]

The earliest tests of underwater deceleration at Holloman were performed by Lt. Zaborowski on the Aeromedical Field Laboratory's portable 20-foot Bopper track. Test "subjects" were blocks of wood immersed in a sugar solution. These were exploratory tests, designed in part simply to aid in the development of test procedures and instrumentation; and much the same can be said of subsequent experiments on

the Bopper and the Daisy Decelerator in which frogs and rainbow trout replaced the wooden blocks.[38] Yet even while this preliminary work was in progress, a contract was negotiated with the Northrop Corporation for design and fabrication of a "fluid-filled, man/animal carrying capsule 6½ feet long and 30 inches in diameter" which could be mounted on a rocket sled for high-speed track experiments. The contract was actually signed on 25 July 1958, but it was revised later in the same year to cover modification of the sled Sonic Wind Number One (AFMDC 5303), which was to carry the fluid capsule. This is the same sled on which John Paul Stapp made his memorable rocket-sled rides at Holloman in 1954.[39]

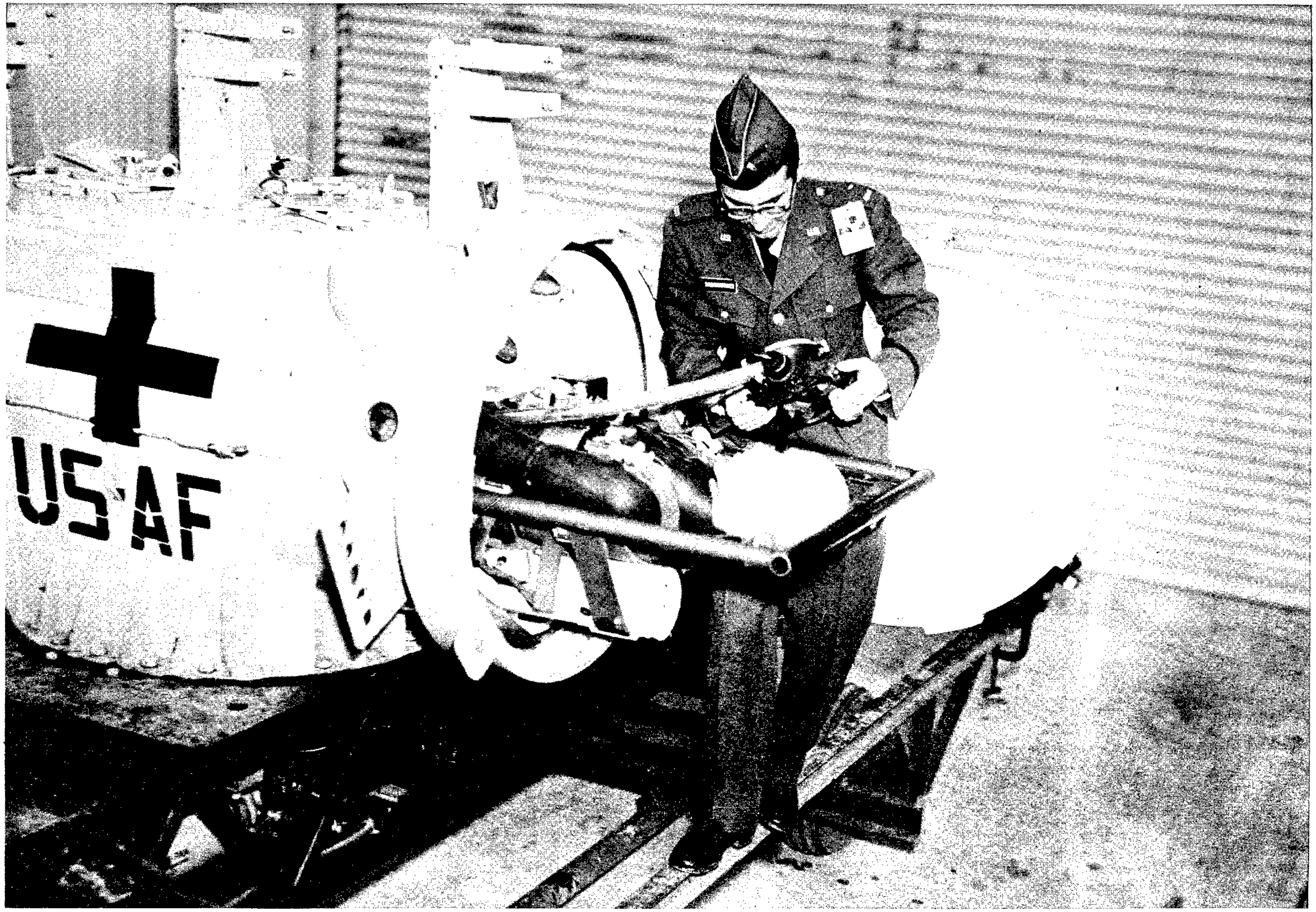
Weighing approximately one ton, the capsule was delivered in the second half of 1959. It was a closed, fixed-volume vessel, designed to be completely filled with water, thus resembling in principle the "Iron Maiden" used by the Navy on its Johnsville centrifuge rather than the man-carrying open "coffin" used in similar experiments at Wright Field. However, it was slightly roomier than either one, which facilitated the study of subject displacement within the water-filled volume. By the time of the capsule's delivery, Holloman scientists had already devoted considerable attention to such operating problems as underwater data collection and communications; and before the first test both Lt. Zaborowski and Capt. Eli L. Beeding immersed themselves in a swimming pool with the skin-diver breathing apparatus and special instrumentation intended for full-scale track experiments.

On 23 November 1959, the inaugural run took place. The capsule carried an anthropomorphic dummy as subject, riding lengthwise in prone position and instrumented for measurements

of both pressure and "g environment." Three movie cameras were mounted on top of the capsule, pointing at "view ports" over the dummy's head, feet, and midsection. The complete instrumentation even included a small microphone inside the subject's face mask. The dummy could not talk, but a pocket watch was tucked inside the mask to produce "living" sounds and thus provide a more realistic check of a communications procedure that could be used later in human tests.[40]

The first run in the series, like all the later runs, used twelve 5 KS 4500 rockets for propulsion; acceleration was moderate (about 5g) but relatively prolonged. The sled attained a top speed of 776 feet per second, followed by 37-g deceleration lasting less than one second. The capsule platform and supporting structure were slightly deformed during the test, necessitating repairs and reinforcement before the next run, but in general both capsule and sled performed satisfactorily. Not much data was obtained from the run, because of failure in the transducer-excitation circuit and the presence of bubbles and water turbulence that interfered with effective camera coverage through the "view ports." However, it was noted after the run that the dummy had been hunched and displaced within the restraining harness, toward the foot end of the capsule.

For the second run, on 14 December, the capsule was reoriented at 90 degrees to the track. Largely because this capsule position increased the air drag, velocity was slightly lower--701 feet per second maximum--and so was the peak deceleration of 28 g. This time telemetry was partially successful, but sled-borne recorder data was only marginal, apparently because of insufficient waterproofing of the accelerometers and pressure transducers attached to



LT. ALBERT V. ZABOROWSKI EXAMINING SKIN-DIVING EQUIPMENT OF AN ANTHROPOMORPHIC DUMMY THAT IS TO TAKE A RIDE IN THE FLUID CAPSULE MOUNTED ON THE SLED SONIC WIND NUMBER ONE.

the dummy. The dummy suffered no apparent displacement, but this was probably due simply to the crosswise orientation of the capsule.

The next two experiments, on 15 January and 11 March 1960, reverted to the standard lengthwise orientation of the fluid capsule. Velocity and deceleration were about the same as on the first run, and the instrumentation worked somewhat better. Waterproofing of the accelerometer clusters by "hot dipping in a wax compound" definitely helped. An attempt at strain-gage measurements, however, was unsuccessful. The January run produced the same type of subject displacement as the first run, but the March test used an altered restraint system, and the dummy's motion was very slight.[41]

The next step was a static test of the fluid-capsule system with a chimpanzee subject. The equipment appeared to function properly--and the subject came through in excellent condition. Then on 13 April the first dynamic test was attempted with a living subject. It was a low-performance run, aiming to repeat the previous levels of acceleration and velocity but come to a coasting stop without using the water brake. Peak deceleration was thus around four g, and instrumentation results, including telemetered strain-gage data, were reasonably satisfactory. Unfortunately, the anesthetized chimpanzee subject appears to have expired on the launch pad, even before the sled was fired.

On 27 April another chimpanzee run was conducted, at a slightly higher performance level: about 8.5 g deceleration for 1.7 seconds. The subject survived the test but died immediately afterward, with pathology clearly indicating drowning and/or too-long anesthesia. Data collection

on the 27 April run was generally successful, even though there was no attempt at strain-gage measurements. But at this point the Aeromedical Field Laboratory decided to interrupt the test program, "to evaluate data and make required changes in the physiological system."[42]

One example of the problems that needed solving was the precise effect of prolonged anesthesia on animal subjects. Another is suggested by the efforts to obtain strain-gage measurements, which were successful only on the 13 April run and showed a definite lack of longitudinal loading. Yet not only was this a low-performance test but also the nature of the restraint system was such that possibly no measurable longitudinal loading could have been detected by strain-gage techniques in any event. Thus the test methods and instrumentation could obviously stand still further improvement. On the other hand, no really fundamental defect had been found in the fluid-capsule system, which clearly held considerable promise; and the Aeromedical Field Laboratory still planned to resume the tests in due course and carry them through to the stage of actual human experimentation.

Mercury Track Tests

In the summer of 1960 the Aeromedical Field Laboratory began still another series of tests using the Holloman track, this time in support of Project Mercury, the man-in-space effort of the National Aeronautics and Space Administration (NASA). As indicated in the preceding chapter, the Holloman laboratory had been designated by NASA to manage the program of animal flights that were to precede actual manned

experiments. This responsibility entailed selection, training, and conditioning of chimpanzee subjects, and it called for the use of several different Holloman test facilities--naturally including the 35,000-foot track.

The high-speed track phase of the Mercury animal program was simply one aspect of acceleration/deceleration studies designed[43]

> ...to determine the physiology and biochemistry of the chimpanzee's response to simulated acceleration-deceleration flight profiles of the Project Mercury flights. A second objective is to expose all programmed orbital flight animals to simulated acceleration-deceleration profiles to determine psychomotor response ability.

Stated differently, these studies aimed both to develop general tolerance data and to establish base-line data on particular animals that might later serve as Project Mercury orbital flight subjects. The 35,000-foot Holloman track was to be used to simulate "the booster or acceleration aspect" of a Mercury satellite launching, while "re-entry deceleration and oscillation" were to be simulated on the human centrifuge at Wright Field* and "water impact deceleration" on the Daisy Decelerator at Holloman.

The Aeromedical Field Laboratory task officer for the Mercury track program was Capt. Norman E. Stingely, of the Bio-Astronautics Branch. The chosen test vehicle was the Lockheed sled, the same that was used in the later Discoverer track tests (Snowball II). And in many respects the

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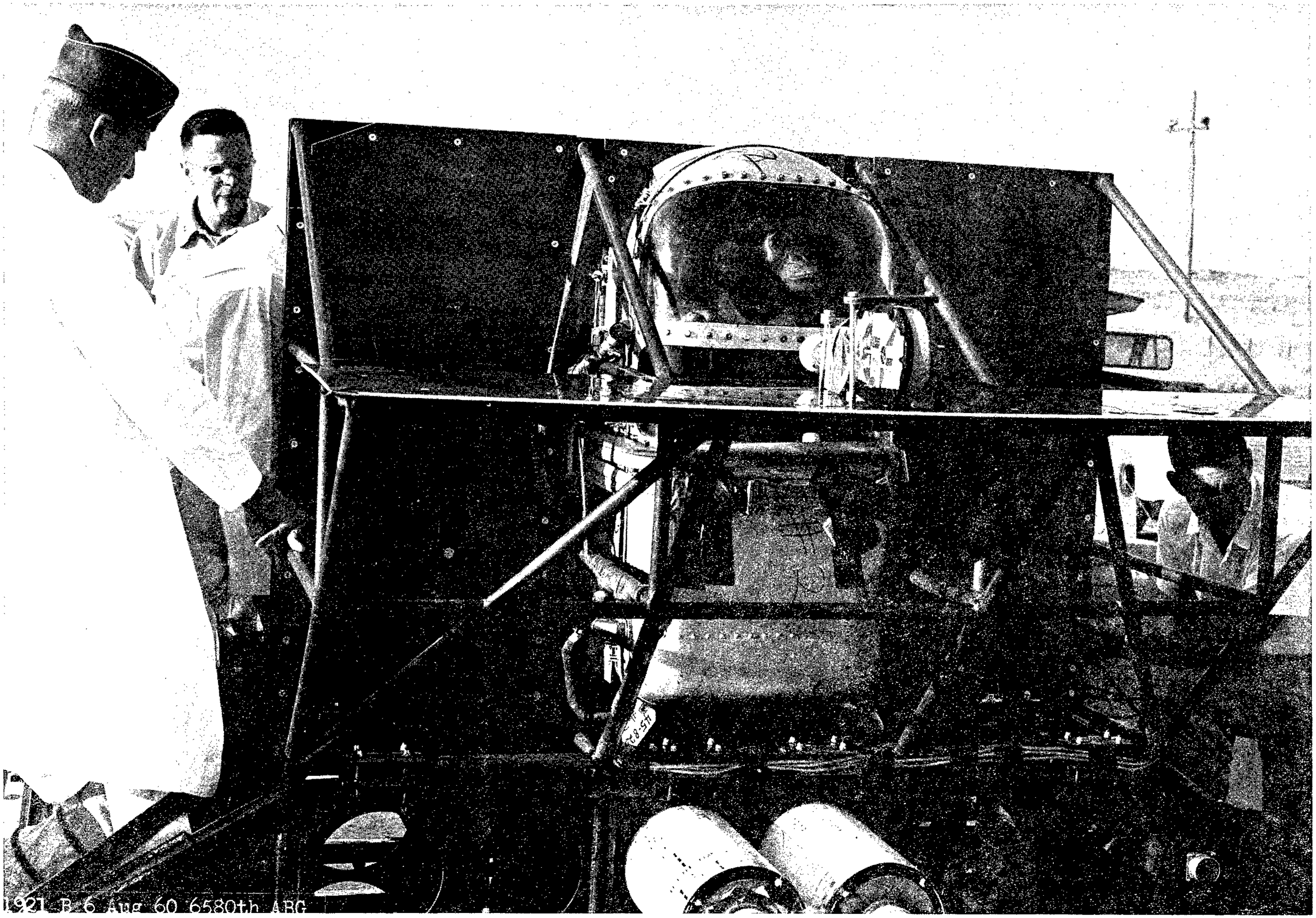
* A later revision of the test plans also calls for centrifuge testing to supplement the long track in studies of the thrust phase. The centrifuge is of course better able to simulate the <u>duration</u> of g, although it cannot equal a track facility in producing the rapid changes in g-level.

Discoverer track program actually laid the groundwork for Mercury. The Mercury program did not attempt anything quite so complicated as the first and second Discoverer runs (Snowball I) but the objectives and techniques of the two track programs still had much in common. The most obvious similarity was the mere fact that both programs aimed to reproduce a two-spiked satellite-launching pattern. This was to be achieved in the Mercury tests by a low-acceleration boost followed after burnout by two distinct water-brake deceleration profiles each reaching a peak of about eight g.[44]

The initial run took place in the early morning of 6 August 1960. The sled had been modified to hold three "flight couches," each capable of accommodating one chimpanzee subject--both to reduce the final cost of the test program and to permit exposure of three different animals to an identical g-profile (something that can never quite be accomplished in separate runs on the long track). But in this first test only one "couch" was occupied; the other two were replaced by ballast. Propulsion was supplied by four 1.8 KS 7800 Sparrow boosters, fired in four stages, but the maximum velocity of 417 feet per second was less than predicted, and thus the water-brake deceleration level also failed to match required performance. A further problem was the water discharge during the braking process, which interfered both with on-board camera coverage and with other instrumentation. (However, the run was immediately followed by a test on the Daisy Decelerator, for water-impact simulation, which provided a 20-g pattern as desired.)[45]

For the next attempt, on 25 August, ballast was substituted for all three "flight couches," and an extra



PROJECT MERCURY CHIMPANZEE, MOUNTED IN "FLIGHT COUCH" ON LOCKHEED SLED, AT CONCLUSION OF 6 AUGUST 1960 RUN (CAPT. STINGELY IS STANDING IN BACKGROUND, FACING CAMERA.)

booster was added on the fourth stage. Velocity was higher--about 575 feet per second maximum--but again there was trouble with the braking water. Indeed at this point a decision was made to change the sled configuration, attaching the Coleman sled as a pusher (and braking) vehicle, with the Lockheed sled as a carrier only. The braking mechanism on the Coleman sled provided for water discharge to the side of the track and was thus expected to eliminate the problem encountered in the previous runs.

The new configuration was checked out on 29 September, again without a subject. Four Viper II-C rockets were fired, in two stages. The maximum velocity (about 510 feet per second) was below expectations, and so was the deceleration level; but at least there was no trouble with water spray. Moreover, it appeared that further adjustment of water-brake dam settings would give essentially the required deceleration performance. After one run cancellation on 7 October due to instrumentation problems, this was actually accomplished in the fourth Mercury track test, on 26 October 1960. A single instrumented chimpanzee subject was used, as in the first run of the series. Velocity was less than predicted--as usual--but each of the two water-brake series nevertheless produced approximately eight g. Captain Stingely and his co-workers thus concluded that an acceptable run profile was at last attained.

Of special interest was the inclusion this time of a psychomotor test (featuring panel lights and a set of levers to press down) in addition to the measurement of acceleration and physiological data. The performance task had been devised by the Aeromedical Field Laboratory's Comparative Psychology Branch. It was programmed for one 30-minute period before the track run, followed by a 30-

minute break, then starting again shortly before firing time. Periods of rest and psychomotor testing continued to alternate until the subject had also experienced a Daisy Decelerator impact run. In the high-speed track run, the chimpanzee suffered neither injury of any sort nor performance decrement, although the run itself was so short that no conclusion was possible as to performance during actual exposure to the programmed force--there was merely no sign of any decrement afterward, resulting from the run.[46*]

Following the 26 October experiment, Project Mercury high-speed track tests were suspended until the time arrives to test "orbital" chimpanzees, i.e., members of the group that will provide candidates for actual satellite launchings. The date of the next run thus depends upon over-all Project Mercury time schedules, and will presumably be sometime in mid-1961; but whenever it comes, both track engineers and the Aeromedical Field Laboratory will now be prepared for it.

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* The Daisy run produced a force of 40 g on the body of the sled and 135 g, for a small fraction of a second, on the subject's chest. The cycle of performance testing had to be terminated prematurely after the Daisy run, because of an equipment failure, but the chimpanzee appeared to be doing well in this as in other respects despite the extreme (though short-lived) deceleration.

NOTES

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2. R & D Project Card (DD Form 613), Project 7850, 31 August 1959.

3. Capt. W. R. Smith, Plans and Programs Division, DCS/O, AFMDC, memo for record, subj.: "NOTS Track runs in support of Project 7850," 20 May 1958.

4. Management Report (ARDC Form 111), Project 7850, 28 October 1959; Holloman Rocketeer, 7 November 1958; interview, Lt. Albert Zaborowski, Biodynamics Branch, Aeromedical Field Laboratory, by Dr. David Bushnell, AFMDC Historian, 31 August 1960.

5. Astrodyne, Inc., McGregor, Texas, News Release AN-7h (February 1959).

6. White Sands Proving Ground, Integrated Range Mission, Informal Data Reduction Report, Project 7850 Task 78505, Human Tolerance to Wind Blast, Run No. 82B... Test Date: 6 August 1958; run records file, Track Projects Branch, AFMDC, folder on run number 794.

7. Interview, Lt. Zaborowski by Dr. Bushnell, 31 August 1960; Informal Data Reduction Report, Project 7850... Test Date: 6 August 1958.

8. Informal Data Reduction Report, Project 7850 Run No. 99-A...Test Date: 29 October 1958; Holloman Rocketeer, 7 November 1958; run records, folder on run number 864.

9. Astronautics, March 1959, p. 17.

10. Interview, Lt. Zaborowski by Dr. Bushnell, 31 August 1960.

11. Critique of 80-4 Documentation (ARDC Hq. Form 0157),

Project 7850, by Col. Jack Bollerud, Dir./Life Sciences, ARDC, 30 April 1959; comment no. 2, Maj. Herbert W. Simmons, Acting Chief, Programs Division, DCS/O, AFMDC, to Mr. Ellis M. Bilbo, Plans and Programs Office, Dir./Advanced Technology, AFMDC, subj.: "Management Reports--Projects 6892 and 7850," 19 May 1959; R & D Project Card, Project 7850, 31 August 1959; interview, Capt. Eli L. Beeding, Chief, Biodynamics Branch, by Dr. Bushnell, 7 March 1961.

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13. James S. Hanrahan and David Bushnell, Space Biology (New York: Basic Books, 1960), pp. 106-108 (and sources cited there); interview, Lt. Zaborowski by Dr. Bushnell, 31 August 1960.

14. Historical Branch, AFMDC, Development of the Nation's Leading Test-Track Facility, 1956-1960 (Vol. II, History of Tracks and Track Testing at the Air Force Missile Development Center), pp. 21-24.

15. Run records, folder on run number 930; interview, Lt. Zaborowski by Dr. Bushnell, 31 August 1960.

16. Interview, Lt. Zaborowski by Dr. Bushnell, 31 August 1960; Aeromedical Field Laboratory, "Historical Data," January-March 1959.

17. New York Times, 8 March 1959.

18. Ibid.; Alamogordo Daily News, 25 February 1959; El Paso Times, 26 February 1959.

19. Interview, Dr. Harald J. von Beckh, Technical Advisor, Aeromedical Field Laboratory, by Dr. Bushnell, 28 August 1959; interview, Lt. Zaborowski by Dr. Bushnell, 31 August 1960. The interpretation of this run in Hanrahan and Bushnell, Space Biology, p. 108 (and actually written by the author of the present history) is frankly oversimplified.

20. Historical Branch, Air Force Ballistic Missile Division, Short Historical Evaluation, WS 117L: Discoverer, Sentry and Midas Chronology 1946-1959.

21. Above, pp. 2-4.

22. Cf. Aeromedical Field Laboratory, "Historical Data," January-March and April-June 1959.

23. Lt. Peter L. Mullins, Track Projects Branch, "The Holloman Track and Aero Medical Testing," 19 March 1959 (special report in Historical Branch files).

24. Track Projects Branch, _Track Test Plan No. 107_ (10 December 1958).

25. _Development of the Nation's Leading Test-Track Facility_, pp. 66-67.

26. Mullins, "The Holloman Track and Aero Medical Testing;" interview, Lt. Zaborowski by Dr. Bushnell, 29 August 1960; run records, folder on run number 909.

27. Interview, Lt. Zaborowski by Dr. Bushnell, 29 August 1960; run records, folder on run number 912.

28. Peter L. Mullins, _Operational Report, Runs 124-A, B, BB and C: Snowball II Run Series_; interview, Lt. Zaborowski by Dr. Bushnell, 29 August 1960.

29. Run records, folders on runs 985 and 991.

30. Mullins, _Operational Report_; run records, folder on run number 992; interview, Lt. Zaborowski by Dr. Bushnell, 31 August 1960.

31. _Evening Star_ (Washington, D. C.), 1 May 1959.

32. Interview, Lt. Col. Edward L. Cole, Director, Bioastronautics Projects, AFBMD, by Dr. Bushnell, 7 October 1960.

33. Aeromedical Field Laboratory, "Historical Data," April-June 1959.

34. _Alamogordo Daily News_, 17, 22, 24 and 27 May 1959 and 4 June 1959.

35. _Short Historical Evaluation, WS 117L: Discoverer, Sentry and Midas Chronology_.

36. _Alamogordo Daily News_, 4 June 1959.

37. _Research in Space Biology and Biodynamics_, pp. 70-71.

38. Aeromedical Field Laboratory, "Historical Data," January-March 1959; R & D Project Card, Project 7850, 2 September 1960; interview, Lt. Zaborowski by Dr. Bushnell, 28 May 1958, 26 May and 2 November 1959.

39. Aeromedical Field Laboratory, "Historical Data," April-June and September-December 1958; R & D Project Card, Project 7850, 31 August 1959.

40. Aeromedical Field Laboratory, "Historical Data," September-December 1958, and "Historical Report," October-December 1959; Holloman Rocketeer, 19 February 1960.

41. Track Projects Branch, Operational Report, Phase I, Runs No. 142-A, B, C, and D. Sonic Wind No. 1 With Water Capsule; Aeromedical Field Laboratory, "Historical Report," October-December 1959; R & D Project Card, Project 7850, 2 September 1960; comments by Lt. Zaborowski on preliminary draft of this chapter, 28 February 1961.

42. Track Projects Branch, Operational Report, Phase II, Runs 142-E and 7-3FL, Sonic Wind No. 1 With Water Capsule; R & D Project Card, Project 7850, 2 September 1960; comments by Lt. Zaborowski, 28 February 1961; interview, Capt. Beeding by Dr. Bushnell, 8 March 1961.

43. Norman E. Stingely, Test Protocol: Acceleration-Deceleration Studies of Project Mercury Chimpanzees (revised as of 23 September 1960), p. 1.

44. Interview, Capt. Stingely by Dr. Bushnell, 18 October 1960.

45. Run records, folder on run number 1272; interview, Capt. Stingely by Dr. Bushnell, 18 October 1960.

46. Run records, folders on runs 1282, 1310, and 1321; interview, Capt. Stingely by Dr. Bushnell, 7 March 1961.

GLOSSARY

AFB	Air Force Base
AFBMD	Air Force Ballistic Missile Division
AFMDC	Air Force Missile Development Center
AMFL	Aeromedical Field Laboratory
AML	Aero Medical Laboratory
ARDC	Air Research and Development Command
Asst.	Assistant
Cmdr.	Commander
DCS/	Deputy Chief of Staff for
DCS/O	Deputy Chief of Staff, Operations
Dep. Cmdr./	Deputy Commander for
Dir.	Director; Directorate
Dir./	Directorate of
FY	Fiscal Year
g	Gravity
ind.	indorsement
ltr.	letter
NASA	National Aeronautics and Space Administration
R & D	Research and Development
RBE	Relative biological effectiveness
SNORT	Supersonic Naval Ordnance Research Track
subj.	subject
TWX	Teletypewriter exchange message
USAF	United States Air Force
WADC	Wright Air Development Center
WADD	Wright Air Development Division

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